Shaping Effects of Three Different Nickel-Titanium Rotary Endodontic File Systems in Root Canals of Mandibular Molars: An Ex-Vivo Study

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ABSTRACT

Introduction: Canal preparation and shaping is one of the major steps in root canal treatment. Study aimed to compare and evaluate the shaping ability of three different rotary Ni-Ti endodontic file systems in root canals of extracted molar teeth.

Material and methods: A total of 60 extracted human mandibular first molar teeth with curvature ranging between 15-30^0 were used in this study. Specimens were embedded in a modified muffle system and sectioned horizontally at three levels before preparation anitind were randomly divided into three experimental groups. Root canal preparation was performed with ProTaper, RaCe and Varitaper Ni-Ti instruments. Cross section images were taken both before and after instrumentation under a stereomicroscope connected to charged couple device (CCD) camera at a fixed position and magnification. Pre and post radiographs and images obtained were analyzed to evaluate the shaping ability (in terms of amount of dentin removed, straightening, transportation and centering ratio) by using image analysis software. The data were analyzed statistically using ANOVA tests.

Results: All the systems maintained canal curvature well. Varitaper and RaCe had better centering ratio and least transportation compared to ProTaper ($P<0.05$) in the apical section. Protaper had higher values of dentin removal ($P<0.05$) at all levels compared to other file systems.

Conclusions: ProTaper removed dentin more, RaCe and Varitaper had better centering and least transportation at all levels,While canals shaped with ProTaper had transportation and less centering ratio at apical level

Keywords: Canal Curvature, Centring Ability, Ni-Ti files, Transportation.

INTRODUCTION

Canal preparation and shaping is one of the major steps in root canal treatment. The aim is to form a continuously tapered shape with smallest diameter at apical foramen and largest at the orifice to allow effective irrigation and filling and not change the original canal curvature. Traditional stainless steel instruments used for canal shaping are time consuming, stiff and often fail to achieve the desired root canal shape, especially in narrow and curved canals. These short -comings of traditional instruments, led to development of nickel-titanium (Ni-Ti) instruments.[1] Ni-Ti rotary instruments have an important role in root canal preparation and enable clinicians to predictably and relatively create tapered preparations, especially in curved canals.[2,3] Parameters to assess the quality of root canal preparation include, cleaning ability, shaping ability and safety issues.[4,5] Recently, the new instrument, Varitaper (Endomax, Equinox, Holland) has been introduced. Varitaper comprises of six safe ended instruments including apical finisher with a gradual increasing taper of 3 to 6% and a variable helical angle. The cross sectional design of Varitaper is trianglar but slightly positive rake angle for efficient cutting dentin. It has a unique cross cut design over cutting edges to reduce stress on instrument for efficient debris removal. Extensive literature review shows paucity of studies evaluating the shaping ability of Varitaper in real or simulated root canals. So the study was done to evaluate the shaping ability of Varitaper rotary Ni-Ti system and compare it with well established rotary Ni-Ti systems like Protaper (Dentsply–Maillefer, Ballaigues, Switzerland) and RaCe (FKG, La Chaux-de-Fonds, Switzerland).

MATERIAL AND METHODS

Selection of root canals

Sixty freshly extracted human permanent mandibular first molars were selected and were kept in normal saline until used. The canals were controlled for apical patency with ISO no 10 k -files Only teeth with fully formed root apices and those whose canal width near the apex was approximately size 15 were included, this was evaluated with size 15 K-file. In each tooth specimen any one canal of the mesial root was standardized to 12 mm length by removing the crown using diamond discs (0.3mm). Working length was established at 9 mm, and was determined by subtracting 0.5 mm from the length at which the tip of a size 15 file could be visualized at the apical foramen viewed under a stereomicroscope (Nikon SMZ 1000, Tokyo, Japan).

Preparation of model

A muffle-block was constructed as given by Aviad et al[6] After sealing the apices with wax, the canals were mounted in the muffle-block using self cure acrylic resin (DPI Cold Cure). After complete polymerization of the resin, the block was removed from the model, the wax removed and the apical foramen exposed. The blocks were sectioned

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horizontally at three sites (coronal, middle and apical) by a thin cutting disk (0.3-mm thick) mounted on a special machine (Cutty, Manfredi, Itlay) for cutting the blocks. Photographs were taken of all three cross-sections of each tooth under a stereomicroscope connected to a charge coupled device (CCD) camera (Nikon digital sight Ds-U1, Tokyo, Japan) at a fixed position. The sections were reassembled in the muffle. Standardized radiographs were taken prior to instrumentation with the file size #10(Dentsply Maillefer, Ballaigues, Switzerland) inserted into the buccal or lingual canal in order to determine the degree of the curvature using periapical Kodak Insight films (Eastman Kodak Company, Rochester, NY). The X-ray tube (Siemens, Heliodent, Germany) was aligned perpendicular to the root canal. The degree of canal curvature was obtained with computer program Motic images 2000, 1.3(Motic China Group LTD). The degree of curvature was determined according to Schneiders (1971) technique, and angle ranged between 15-300 were included. After the preoperative radiograph, the specimens were randomly divided into three groups.

Group I: canals prepared with ProTaper
Group II: canals prepared with RaCe
Group III: canals prepared with Varitaper

Root canal instrumentation

All canals were prepared by a single experienced operator. In each group shaping was done with the specified instrument using a 20:1 reduction handpiece powered by a torque limited endodontic motor (Endo-Mate DT; NSK, Tokyo, Japan). Preparation was completed in a crown-down manner according to manufacturers' instructions using a brushing technique. Each instrument was used to enlarge five canals only and then discarded. The instrument sequence for each group is described in Table (A). Copious irrigation with 2.0 ml 2.5% NaOCl solution followed by 2.0 ml of a 17% EDTA was used throughout the preparation. After preparation, standardized radiographs were taken in the same previous position with the master instrument in-situ using X-ray platform. Curvatures of the prepared canals were computed and were compared with the previous ones. One blind examiner evaluates the specimens root curvatures. After instrumentation, all sectioned canals were separated, and then photographed in the same manner as pre-treatment photographs. The shaping ability of the rotary instruments was evaluated using the computer program Motic images 2000, 1.3(Motic China Group LTD)

Assessment of the canal preparation

The parameters used to evaluate the shaping ability of the file systems were straightening, cross sectional area (amount of dentin removed), transportation, and centering ability) using the computer program Motic images 2000, 1.3(Motic China Group LTD)

1. Straightening: - was determined by the change of curvature of pre and post instrumentation images. (Figure 1 and Figure 2)
2. Cross-sectional area: each section was measured both before and after instrumentation. (Figure 3 and Figure 6)
3. Centering ability: of the instruments towards the original canal was evaluated by the ratio of (a1-a2) ÷ (b1-b2) or (b1-b2) ÷ (a1-a2) according to the method developed by Gambil et al 1996), in this formula, a1 and b1 represent the thickness of the internal and external sides of the canal wall, respectively, mesiodistally, before instrumentation and a2 and b2 after instrumentation(pic 5 and pic 6). If these numbers were not equal, the lower number was considered as numerator of the ratio. A result with ratio 1 indicates that the canal has remained centered and a result less than 1 indicates deviation of the canal outward, and result of more than one show that the canal deviates inward.
4. Transportation: was determined by measuring the shortest distance from the edge of uninstrumented canal to the periphery of the root (mesial and distal) and then comparing this with the same measurements obtained from the instrumented images. The following formula was used for the calculation of transportation at each level for both groups: (a1-a2)-(b1-b2),

STATISTICAL ANALYSIS

Analysis of data, the data were analyzed with ANOVA tests at a significance level 0.05 and 0.01 using SPSS 16.0 (SPSS Inc.Chicago IL, USA).

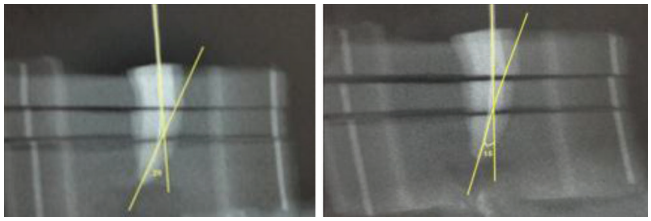

Figure-1: Pre instrumentation curvature measurement of canals; **Figure-2:** Pre instrumentation curvature measurement of canals

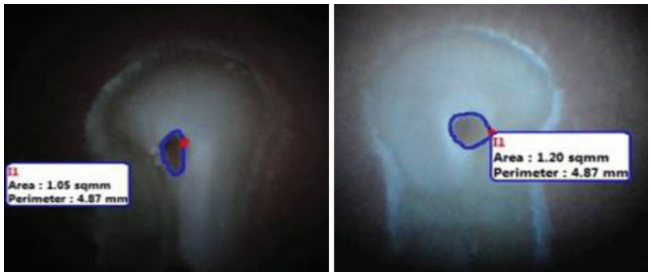

Figure-3: Preinstrument cross section area measurement; **Figure-4:** Post instrument cross section area measurement

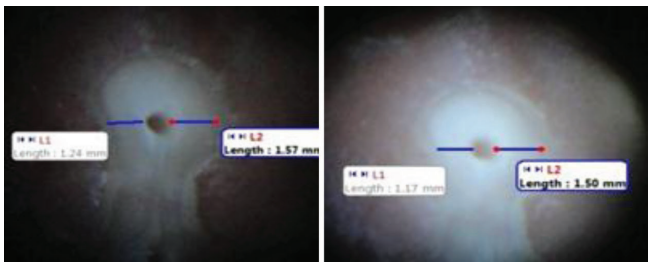

Figure-5: Thickness of walls measurement pre instrumentation; **Figure-6:** Thickness of wall measurement postinstrumentation

RESULTS

Straightening

The mean straightening (change to degree of curvature) is summarized in table 1. All the systems maintained the root canal curvature well. But some amount of straightening occurred in all groups which was statically insignificant ($p > 0.05$)

Cross sectional area

The mean area of each cross section is shown in table 2 and mean and SD of dentin removed is shown in table 3. ProTaper showed significantly ($p<0.05$) more dentin removed followed by varitaper and Race at all levels.

S. No.	Group	N	Mean	SD
1.	I	20	6.07	4.39
2.	II	20	5.50	3.57
3.	III	20	5.59	5.05
P Value			0.894	
F (ANOVA)			0.894	

Table-1: Mean degree of straightening among groups (change of curvature) (mean SD)

Transportation

Mean and SD values of transportation after instrumentation at different levels in study groups is shown in table 4.Race and varitaper had least values of transportation but canals prepared by ProTaper showed statically significant ($p<0.005$) mean values in apical section.

Centering ability

Mean values for centering ratio after instrumentation is shown in table 5. Varitaper and RaCe systems had higher values of centering ratio but protaper had lower values of centering ratio in apical section ($p<0.05$).

DISCUSSION

The present study evaluated the canal preparation using three rotary systems ProTaper, RaCe and Varitaper on natural human teeth. The parameters assessed were, root canal curvature changes, canal cross section, canal transportation and centering ratio. Human teeth were chosen as they simulate clinical conditions better than acrylic blocks. Despite variations in the morphology of natural teeth, efforts were made to ensure comparability of the experimental groups. The teeth in all groups were balanced

S No	Group	Coronal				Middle				Apical			
		Pre		Post		Pre		post		Pre		post	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1.	Protaper	0.85	0.15	1.16	0.14	0.53	0.12	0.72	0.14	0.30	0.09	0.41	0.12
2.	Race	0.82	0.16	0.95	0.16	0.55	0.16	0.62	0.16	0.30	0.09	0.34	0.09
3.	Varitaper	0.82	0.16	1.28	0.34	0.55	0.13	0.66	0.14	0.30	0.10	0.38	0.09

Table-2: values (Mean, SD) for area (mm^2) of each cross section of pre and post instrumentation

S.No	N	Group	Coronal		Middle		Apical	
			Mean	SD	Mean	SD	Mean	SD
1.	20	I	0.31	0.09	0.19	0.07	0.11	0.06
2.	20	II	0.13	0.04	0.08	0.02	0.04	0.01
3.	20	III	0.22	0.33	.0.11	0.01	.07	0.03
F (ANOVA)			39.91		29.13		15.46	
"p"			<0.001		<0.001		<0.001	

Table-3: Mean and SD of dentin removed at different levels

SN	Group	N	Coronal		Middle		Apical	
			Mean	SD	Mean	SD	Mean	SD
1.	I	20	0.17	0.05	0.14	0.02	0.12	0.04
2.	II	20	0.14	0.02	0.12	0.04	0.06	0.02
3.	III	20	0.15	0.04	0.13	0.02	0.05	0.01
F (ANOVA)			2.459		1.570		17.173	
"p"			0.195		0.450		0.000	

Table-4: Mean and, SD of Transportation at Coronal, Middle and Apical Levels in three groups under study (mm)

SN	Group	N	Coronal		Middle		Apical	
			Mean	SD	Mean	SD	Mean	SD
1.	I	20	0.54	.09	0.57	0.10	0.52	0.11
2.	II	20	0.53	0.09	0.57	0.09	0.65	0.11
3.	III	20	0.57	0.11	0.60	0.06	0.68	0.05
F (ANOVA)			2.559		1.070		17.173	
"p"			0.125		0.350		0.000	

Table-5: Mean and SD centering ability(ratio) at Coronal, Middle and Apical Levels in three groups

with respect to angle, length and dimension. In addition only mesial root of mandibular molar teeth, in which an ISO size 15 K file fits tightly at apical third were included in the study.

Cross sectional area

This parameter provides information about the amount of dentin removed. The comparison of the pre and post operative photographs of root canal diameter enables the evaluation one of the most important requirement of root canal preparation, that is, the prepared canal should completely include in the original canal and no unprepared area should remain. Using a modification of the Bramante technique, pre and post instrumentation photographs of the root canal diameter were measured.

All three kinds of files used in this study shaped the canal cross section similarly. ProTaper showed significantly ($p < 0.05$) more dentin removal followed by Varitaper and RaCe at different cross sectional levels i.e. coronal, middle and apical. ProTaper removed mean amount of 0.31, 0.19 and 0.11mm^2, RaCe removed mean of 0.13, 0.08. And 0.04mm^2 and Varitaper removed mean of 0.22, 0.11.and 0.07mm^2 at coronal, middle, and apical levels respectively. The greater amount of dentin removal of ProTaper than RaCe has been confirmed by other investigations.[7] This is probably due to increased taper of proTaper shaping files of up to 19% whereas RaCe instruments are available only with tapers of maximum 10%. Varitaper removed less dentin compared than ProTaper and greater amount than RaCe instrument. The reason may be that Varitaper file has taper up to 14% (OW file) which is more than RaCe and less than Protaper file.

Straightening

Refers to whether a root canal instrument maintains the original shape of the curved canals and also provides information about the position of removed material. Removal of infected dentin should be performed uniformly on the outer as well as on the inner side of the root canals curvature. Root canal straightening is frequently determined as the difference between angle of curvature assessed before and after instrumentation.

The straightening of curved root canals represents a central problem during root canal preparation. Several studies confirmed that elbow-zip formation occurred in 4.5-100% of the specimens.[8,9] Because of the greater flexibility of Ni-Ti instruments a superior ability to maintain curvature even in severely curved root canals has been described10,11.

In the present investigation the final apical preparation diameter in the ProTaper was a size 25 (Finishing file no 2), final apical preparation diameter RaCe group was a size 25 and the same apical size i.e. 25 was in Varitaper. This was done to investigate the shaping ability of three experimental groups under identical experimental conditions. All the systems in present study maintained root canal curvature well and mean of change in canal curvature, was 6.070, 5.500 and 5.590 for ProTaper, RaCe and Varitaper group respectively. However, the difference among the groups was not significant statistically ($P > 0.05$). Results regarding straightening of Protaper and RaCe in present study are in accordance with previous studies.[12] Varitaper recently introduced Ni-Ti system and to date no data is available on shaping ability.

In contrast Schafer et al 2004[13,14] reported that RaCe system maintained original root canal curvature better and showed less straightening in comparison with proTaper system in Schafers study simulated canals were used whereas in our study natural human canals were used. Certainly simulated canals do not simulate clinical conditions and have less microhardness than natural teeth. Despite all Ni-Ti systems in the present study maintained canal curvature well, but some amount of straightening has occurred in all groups though the difference among groups was not statistically significant and the order of straightening was, ProTaper >Varitaper > RaCe and this could be attributed to different taper of final apical preparation diameter among tested groups. For example F2 in ProTaper has 7%; RaCe has 4% and Varitaper with 3-6% taper.

Transportation and Centering ability

Centering ability of instrument refers to dimension and direction of canal transportation during root canal instrumentation. Regardless of instrumentation technique, cleaning and shaping procedures invariably lead to dentin removal from canal walls. However, excessive dentin removal in a single direction within the canal rather than in all directions equidistantly from main tooth axis causes what is known as canal transportation.

The main parameters used to evaluate shaping are to protect the curvature of the canal and maintain good centering ability. Transportation is caused by the tendency of instrument to return to its original straight shape when inserted into a curved root canal.[15,16] An instrument that remains centered reduces the risk of transportation, zips, elbows, or other mishaps.[17] Moreover, safe and non-cutting tip allows instrument to move in the canal properly and remain central within the canal.[18] Flexibility of Ni-Ti instruments can explain this property. In this study Race and Varitaper rotary files had better centering ability and least transportation at each level, however canals prepared with ProTaper showed transportation towards outer aspect and had lower value of centering ratio in apical section. This finding is consistent with previous results obtained in study of Javaheri et al, 2007[19] compared apical transportation of Hero 642, RaCe and ProTaper. They also suggested in shaping canals with a complex curvature, especially during apical preparation, less tapered and more flexible Ni-Ti file systems like RaCe should be used. It is recommended that the proTaper file system be implemented in combination with other less tapered and more flexible systems to avoid apical transportation.

The current study also confirms the results of previous study in which canal aberrations, of ProTaper, Mtwo, BioRaCe and BioRaCe + was evaluated Bonaccorso et al 2009.[4] These aberrations caused by ProTaper in apical section might be result of progressive taper along the cutting surface of

these instruments, in combination with sharp cutting edges Schafer et al 2004.[13] Varitaper had better centering ratio and least transportation which could be attributed to non-cutting Roane tip which minimizes the risk of apical and lateral perforations as well as ledge formations. Like RaCe the cross sectional design of varitaper is trianglar but slightly positive rake angle and gradual taper of 3-6% 0f apical finisher file might be the reason of least aberrations in apical section.

CONCLUSION

ProTaper removed dentin more, at coronal and middle portions, than Race and Varitaper instruments. Canals prepared with Varitaper had optimum amount of dentin removal at different levels where as RaCe removed less than Varitaper. All the rotary NiTi systems used in the study maintained original canal curvature. However canal prepared with ProTaper had some straightening than RaCE and RaCe and varitaper had better centering and least transportation at all levels i.e. coronal,middle and apical. While canals shaped with ProTaper had transportation at apical level. The varitaper recently introduced Ni-Ti rotary system had better canal shaping in this study. Further research is necessary to evaluate the shaping ability of Varitaper rotary file system with other currently available rotary Ni-Ti systems.

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